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DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS



THE
BULLETIN
OF THE
BEACH EROSION BOARD
OFFICE, CHIEF OF ENGINEERS
WASHINGTON, D.C.

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JULY 1, 1948

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BEACH EROSION BOARD

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PUBLICATION OF

THE BEACH EROSION BOARD

CORPS OF ENGINEERS

WASHINGTON 16, D. C.

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NO. 3

TO THE MEMBERS, EMPLOYEES AND FRIENDS OF THE BEACH EROSION
BOARD:

A retiring board has found me unfit for service of any kind.

I am very grateful to my fellow-members for the kindness and courtesy with which they have always treated me. Most of them are much more familiar than I am with the technical problems involved. They have given me constant support and it has been a great privilege to work with men of so much ability.

Throughout my career I have always enjoyed my association with the civil employees of the Corps of Engineers, a wonderful body of men. The staff of the Beach Erosion Board has been no exception. Their members have been the most learned professionally of all the groups which I have had the privilege to lead, and have been no less loyal than my other friends in the Civil Service. I am indeed grateful to them for their support.

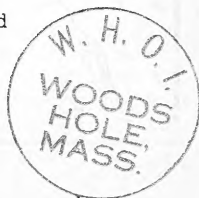
I shall preserve very agreeable memories of the friends of the Board whom I have met along all our coasts. They have been good friends and kind critics. They constitute a community scattered over the nation from whom I am very sorry to separate myself.

However, in my present physical condition, there is no sense of rebellion. It is no use to quarrel with fate. I transmit to my successor an organization of which I am proud. I am sure that he will avoid many of my mistakes. He cannot however be more interested than I have been in my work or more thankful to those who have made the work so pleasant.

C. L. Hall

C. L. HALL

Colonel, USA Retired



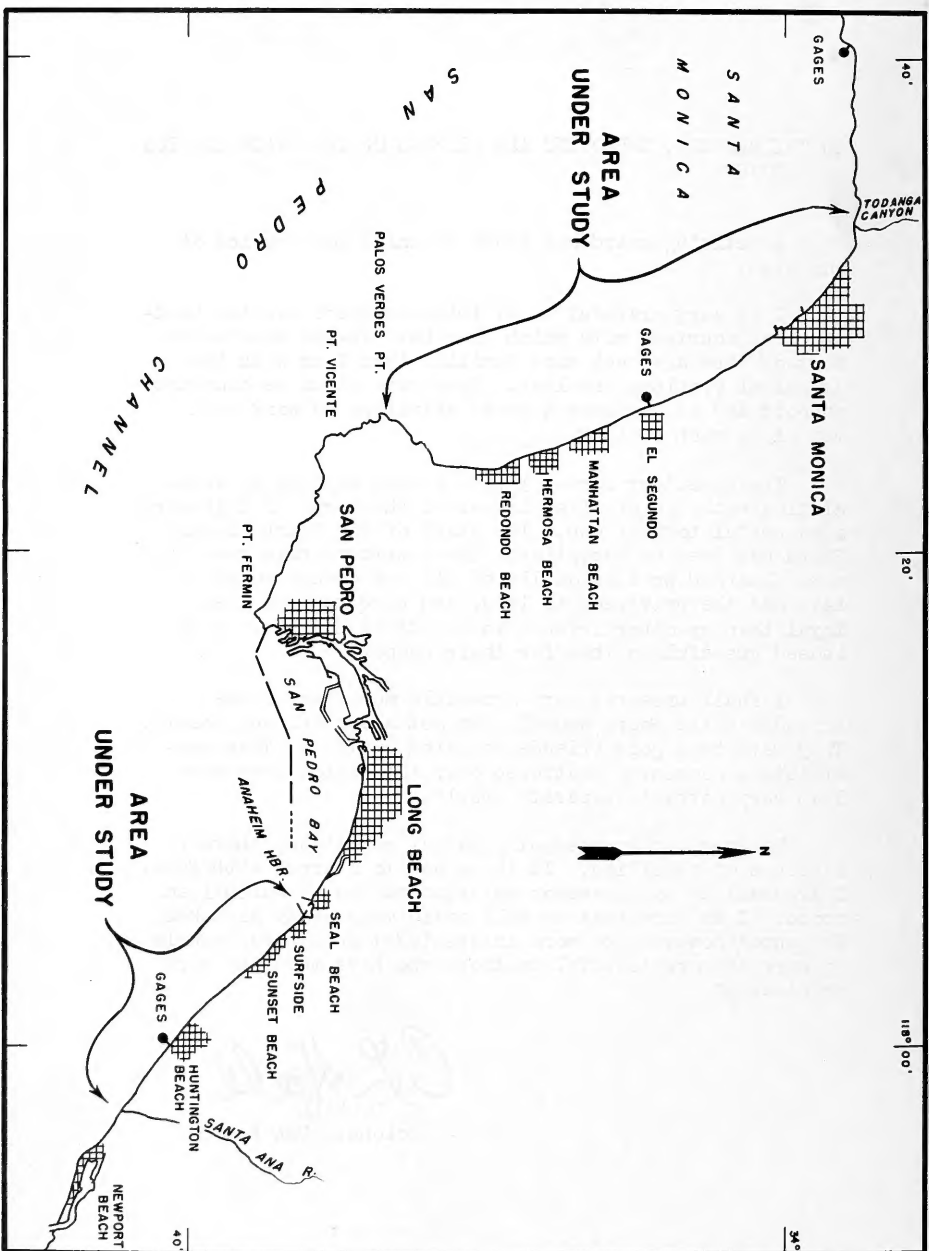


FIGURE 1

LITTORAL DRIFT STUDY LOS ANGELES, CALIFORNIA

A complete knowledge of the mechanics of the littoral movement of beach material is of primary importance in planning beach improvement projects. This fact has long been recognized by the Beach Erosion Board but little work has been done in this field due to the large expenditures required in providing sufficient material for a controlled field test.

Early in 1948 it was found that artificial beach filling at Surfside near Anaheim Bay, California, and at Santa Monica Bay near the Los Angeles sewer outfall at El Segundo, provided suitable areas for controlled tests, in two adjacent embayed areas separated by a rocky headland. See Figure 1.

In the Anaheim Bay area approximately 1,100,000 cubic yards of material were dredged from the harbor entrance and deposited on the beach in front of the Surfside and Sunset Beach colonies to be distributed down-drift by the natural forces.

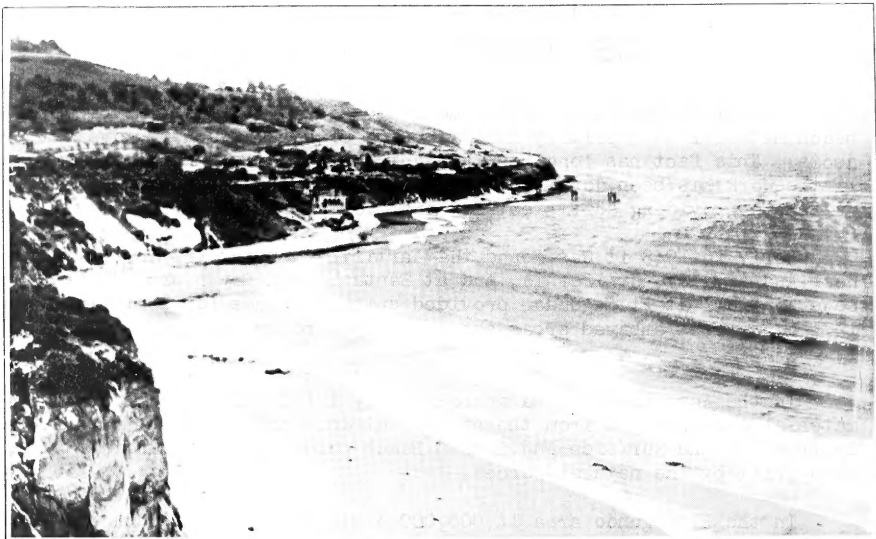
In the El Segundo area 14,000,000 cubic yards of material are being supplied to the beach through a construction project which required the removal of sand dunes to provide a site for a new sewage treatment plant.

The situation and characteristics of the two artificial beaches are considerably different.

The shore line in the Anaheim Bay area runs in an east-west direction, is partially protected from wave action by Catalina Island and has relatively flat bottom slopes. The shore line in the Santa Monica Bay area runs in a north-south direction, is less protected by offshore islands and has a relatively steeper bottom slope.

In these two adjacent yet relatively different natural laboratories the Beach Erosion Board hopes to obtain information leading to the correlation of the volumetric littoral movement of sand deposited on these beaches with the natural forces producing this movement.

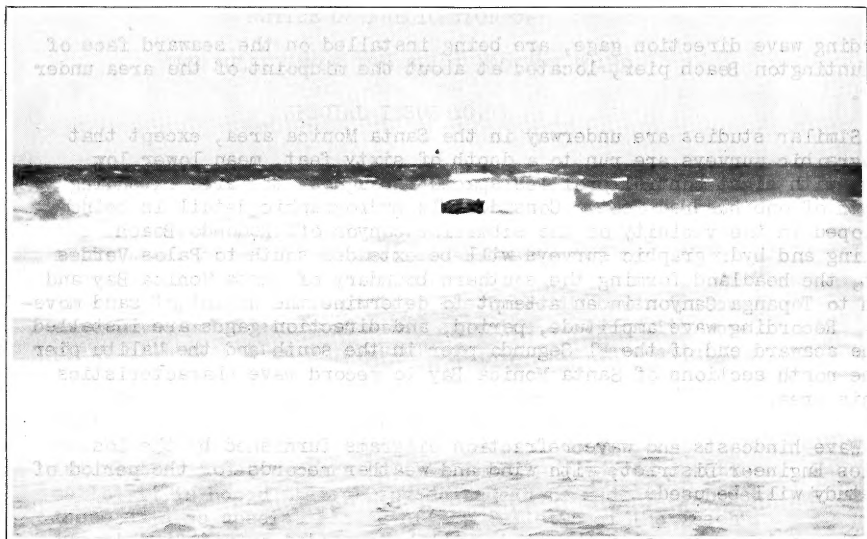
In the Anaheim Bay area, hydrographic profiles are being taken at approximately one-half mile intervals, with more frequent profiles where the shore line is irregular or where the sand is in rapid movement. These profiles extend to a depth of thirty feet mean lower low water, with four profiles spaced through the area extended to a depth of sixty feet to detect any deep water movement of sand that might be present. A topographic survey has been made of the shore area. The profile surveys will be repeated at monthly intervals, or as frequently as may be necessary to detect and measure sand movement. Extensive sand sampling is in progress, both on the beach and offshore, as an aid in tracing the source and rate of sand movement. Studies will also be made of sand in suspension, currents, and rate of littoral drift in the surf zone. A recording gage of the step-resistance type to record wave amplitude and period, along with a



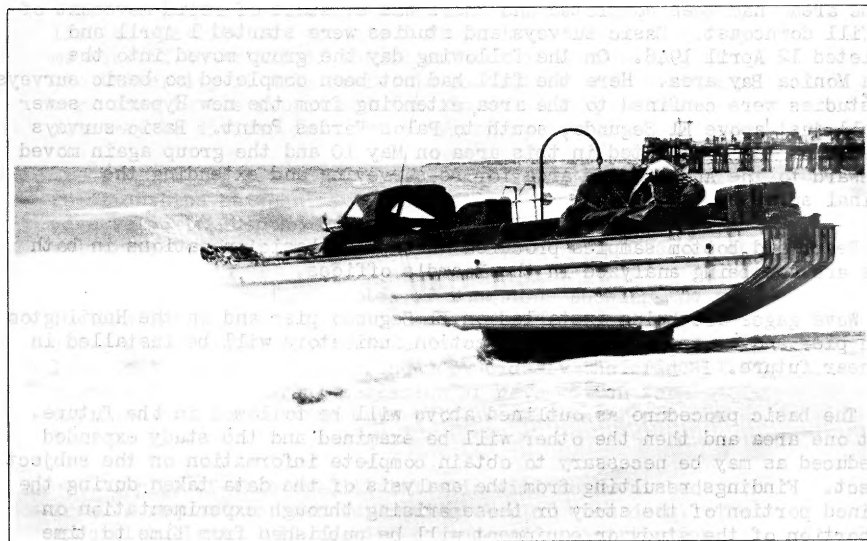
VIEW OF BEACH, PALOS VERDES POINT IN BACKGROUND - APRIL 1948



MALAGA COVE-SOUTH OF REDONDO BEACH-DUKW MOVING SEAWARD-6 FOOT SURF



HERMOSA BEACH - DUKW COMING ASHORE - 6 FOOT SURF - APRIL 1948



REDONDO BEACH - DUKW ENTERING WATER - 2 TO 3 FOOT SURF - MAY 1948

recording wave direction gage, are being installed on the seaward face of the Huntington Beach pier, located at about the midpoint of the area under study.

Similar studies are underway in the Santa Monica area, except that hydrographic surveys are run to a depth of sixty feet, mean lower low water, with eight control profiles spaced throughout the area extending to a depth of one hundred feet. Considerable hydrographic detail is being developed in the vicinity of the submarine canyon off Redondo Beach. Sampling and hydrographic surveys will be extended south to Palos Verdes Point, the headland forming the southern boundary of Santa Monica Bay and north to Topanga Canyon in an attempt to determine the extent of sand movement. Recording wave amplitude, period, and direction gages are installed on the seaward end of the El Segundo pier in the south and the Malibu pier in the north sections of Santa Monica Bay to record wave characteristics in this area.

Wave hindcasts and wave refraction diagrams furnished by the Los Angeles Engineer District, with wind and weather records for the period of the study will be used.

The various phases of the study will be expanded or modified depending on conditions met in the field as the project unfolds. The Anaheim Bay area was selected for the first phase of the study since the sand fill in the area had been completed and there was evidence of rapid movement of the fill downcoast. Basic surveys and studies were started 1 April and completed 12 April 1948. On the following day the group moved into the Santa Monica Bay area. Here the fill had not been completed so basic surveys and studies were confined to the area extending from the new Hyperion sewer outfall just above El Segundo, south to Palos Verdes Point. Basic surveys and studies were completed in this area on May 10 and the group again moved southward to the Anaheim Bay area for re-surveying and extending the original surveys.

Beach and bottom samples procured during the basic operations in both areas are now being analyzed in the Board's offices.

Wave gages are being installed on El Segundo pier and on the Huntington Beach pier and accompanying wave direction indicators will be installed in the near future.

The basic procedure as outlined above will be followed in the future. First one area and then the other will be examined and the study expanded or reduced as may be necessary to obtain complete information on the subject project. Findings resulting from the analysis of the data taken during the outlined portion of the study or those arising through experimentation on any portion of the study or equipment will be published from time to time in this Bulletin.

NOTICE OF PUBLICATION OF
THE BULLETIN OF THE BEACH EROSION BOARD
SPECIAL ISSUE NO. 1

The purpose of the regular quarterly issues of the Bulletin of the Beach Erosion Board is to disseminate to the interested public timely information regarding research activities, cooperative beach erosion studies, and other items of interest dealing with the subject of coastal erosion. It is the intent that the Bulletin cover to some extent the publications of other agencies dealing with some phase of the problem of coastal erosion from wave attack.

In connection with the latter intent it has been found that on some occasions other agencies or authors have unpublished data which are believed to be of considerable interest to other workers in this field. Whenever practicable, it is hoped that arrangements can be made to publish these data as special issues of the Bulletin of the Beach Erosion Board.

The first special issue of the Bulletin will accordingly present a collection of data which has received only limited distribution to date. These data were prepared by members of the staff of the Department of Engineering of the University of California, in connection with contract work done by the Department for the U. S. Navy. These data may be divided into two categories, as follows:

1. A set of 20 graphs expressing various useful relationships between wave height, wave length, wave period, wave velocity, depth of breaking, wave refraction, wind velocity, fetch, decay distance, and other variables.
2. A set of tables of functions showing the relationships of the d/L_0 ratio and the d/L ratio to each other and to other determinate features of water waves. In effect, these tables define very closely the gradual changes in the internal mechanics of wave motion for various positions of the wave between deep water and the breaker line.

Copies of this special bulletin will be furnished free on request to agencies having need of such data. The special bulletin will receive no automatic distribution. Requests for copies should be addressed to:

The Resident Member
Beach Erosion Board
Department of the Army, Corps of Engineers
5201 Little Falls Road, N. W.
Washington 16, D. C.



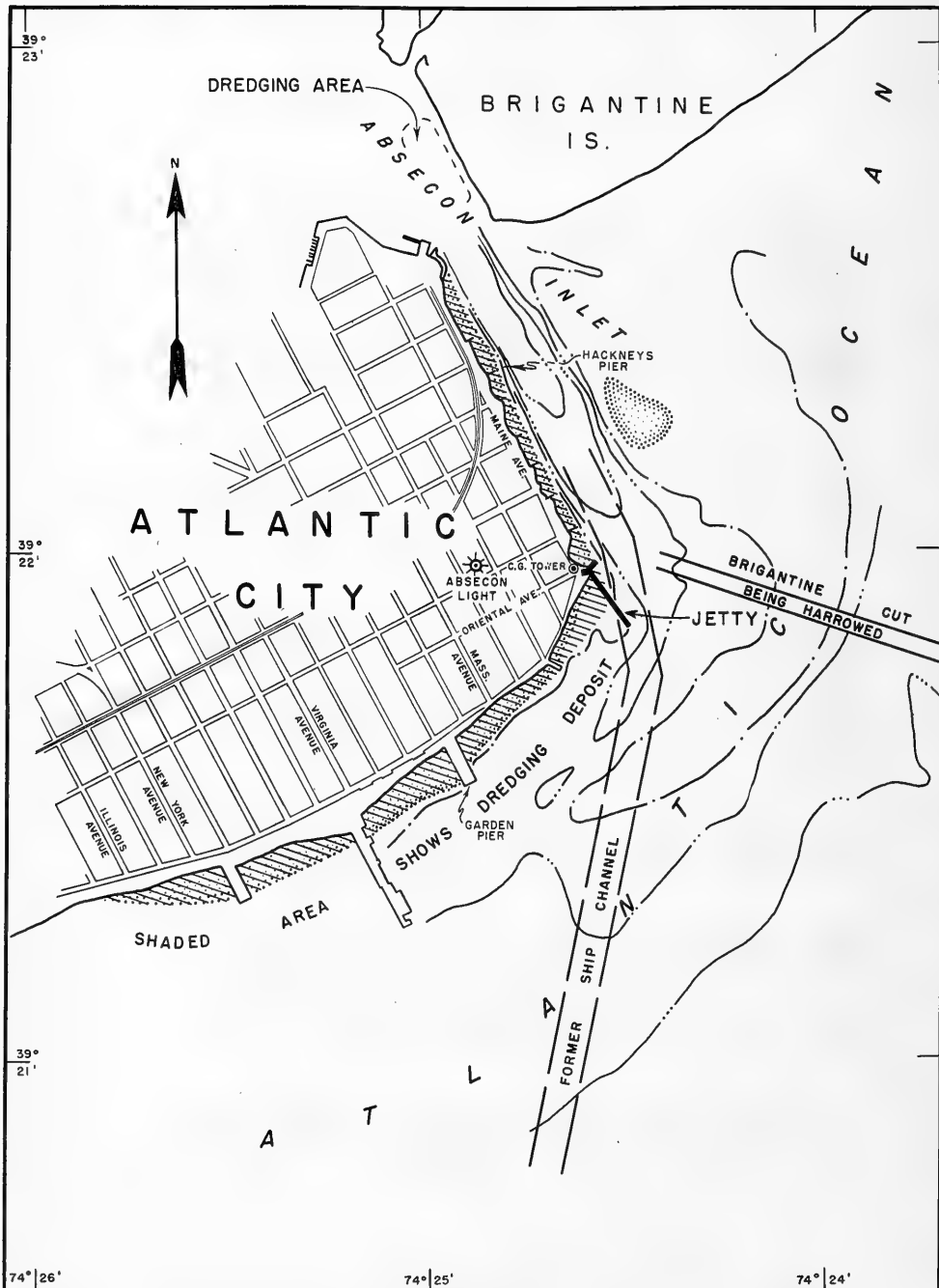


FIGURE 1

BEACH AND CHANNEL IMPROVEMENT MEASURES AT ATLANTIC CITY, NEW JERSEY

Atlantic City has become one of the outstanding seashore resorts of the country largely because of its excellent beach. The approximate stability of the beach since the founding of the community encouraged the investment of millions of dollars in hotels and other recreational property. Its width and safeness have made it a popular summer resort for visitors not only from adjacent states but from all parts of the country.

Within the last decade extensive erosion has developed adjacent to Absecon Inlet and the high water line has receded beneath the boardwalk, seriously threatening many valuable buildings. The 1944 hurricane destroyed most of the boardwalk in this area and the well-known Heinz Pier. The remainder of the pier was determined to be unworthy of rebuilding and has been removed. The erosion had become so alarming by last year that city officials decided that immediate measures for improvement and protection of this portion of the city were imperative. The area is shown on the accompanying sketch, Figure 1.

The plan adopted by the city, to be constructed with State engineering advice and financial aid, comprises principally a long stone jetty at Absecon Inlet and sand fill. A jetty, about 800 feet long, with top 14 feet wide at an elevation about 7 feet above mean low water was built at the bend of the jetty to protect the beach northwest of the jetty. These structures are shown on Figure 2.

The plan for sand fill contemplated restoration of the beach on both sides of the new jetty, westward for a distance of about 1 mile and northward along Maine Avenue. Approximately one million cubic yards of sand were pumped by hydraulic dredge from the west end of Brigantine Island to these uptown beaches, thus building the beaches up for a width of 400 feet from the boardwalk in the central section and about 200 feet in the inlet section along Maine Avenue. Figures 2 to 5 show these beaches before, during, and after placement of the sand fill.

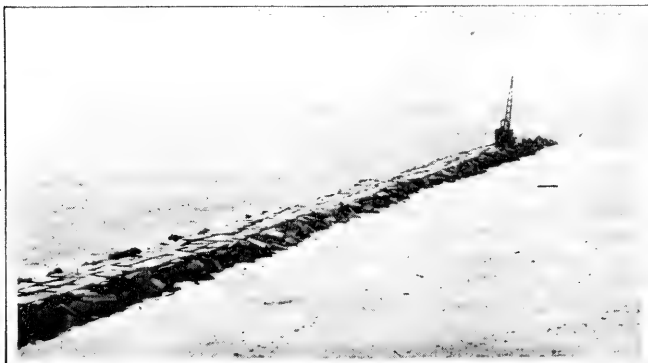
A total of 125 men were engaged in the \$597,000 project to transport 950,000 cubic yards of sand to the uptown beaches through a pipe line 27 inches in diameter. The State agreed to contribute \$232,750 toward the project. This is the largest project of its kind in which the State has participated.

The pipe line was carried across the channel to the beach on pontoons for a distance of about 1,500 feet. Navigation was maintained by opening of the pipe line upon demand.

The dredging company experienced two mishaps, one when the pontoon-supported 27-inch pipe line was snapped by a 30-mile per hour wind during the beginning of the project and later the project was halted again due to a strong tide which swept a 110-foot fishing boat, the "Sea King", against the pipe line.



ORIENTAL AVENUE JETTY UNDER CONSTRUCTION - MARCH 24, 1948



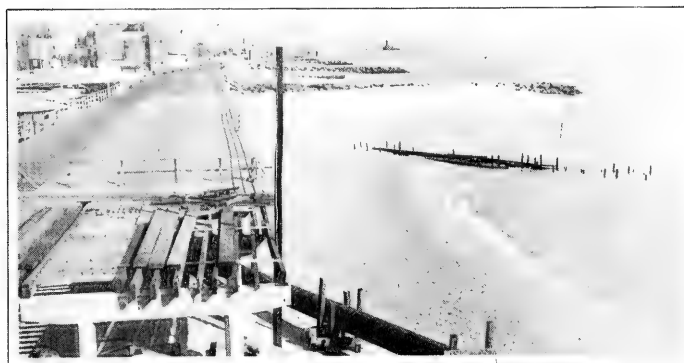
ORIENTAL AVENUE JETTY NEARING COMPLETION AND RESTORED BEACH
MAY 31, 1948



RESTORED BEACH EAST OF GARDEN PIER-MAY 31, 1948



MARCH 16, 1948 — BEFORE



APRIL 5, 1948 — AFTER

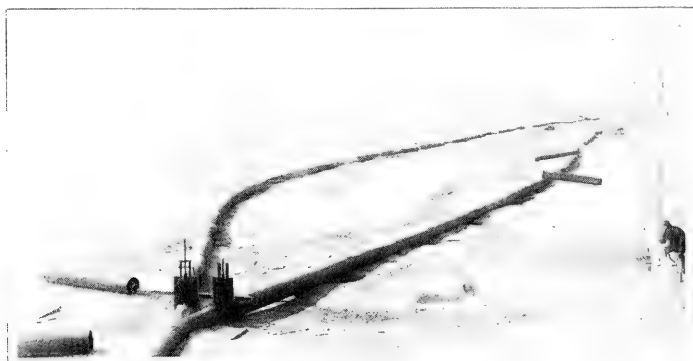


MAY 31, 1948 — AFTER (PART OF FILL LOST)

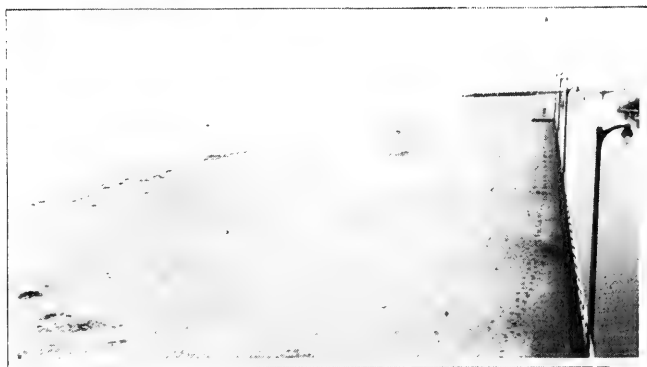
BEACH RESTORATION OF WEST SHORE OF ABSECON INLET NORTHWEST OF C.G. TOWER



MARCH 16, 1948 — BEFORE



APRIL 5, 1948 — DURING



MAY 31, 1948 — AFTER

**BEACH RESTORATION WEST OF C.G. TOWER
AT ABSECON INLET**

FIGURE 4



BEACH RESTORATION COMPLETED WEST OF C.G. TOWER AT ABSECON INLET — MAY 31, 1948



BEACH RESTORATION ON WEST SHORE OF ABSECON INLET. DISCHARGE PIPE IN OPERATION IN BACKGROUND. SOUTH FROM HACKNEY'S PIER — MAY 31, 1948

In addition to the work already in progress, plans for beach improvement include the following:

1. Riprap protection along the Maine Avenue bulkhead. Because of the swift currents in the deep channel along this west shore of the inlet, local authorities believe that maintenance of beaches here will be difficult and that riprap protection will be necessary to prevent undermining of the bulkhead.

2. Construction of one or more groins along the beach between the Oriental Avenue jetty and the west limit of beach restoration in the vicinity of Illinois Avenue. The purpose of these structures is to prevent or reduce the loss of the new fill from the beach.

An attempt is being made by the Corps of Engineers to open a channel eastward of the present channel by "harrowing" the bar. A steel frame fitted with projecting spikes, or teeth, is pulled along the bottom by two tugs in much the same manner as a farmer harrows a plowed field. By continually traversing the same course it is hoped that the hard-packed bar sand can be loosened sufficiently to be transported by inlet currents, thus providing an incipient channel. This channel may be enlarged and deepened by the natural flow ultimately resulting in the new channel becoming the principal navigable channel for the inlet.

* * * *

THE USE OF HISTORICAL SURVEYS IN BEACH EROSION STUDIES

Harold A. Ward
Chief, Drafting and Reproduction
Branch, Beach Erosion Board

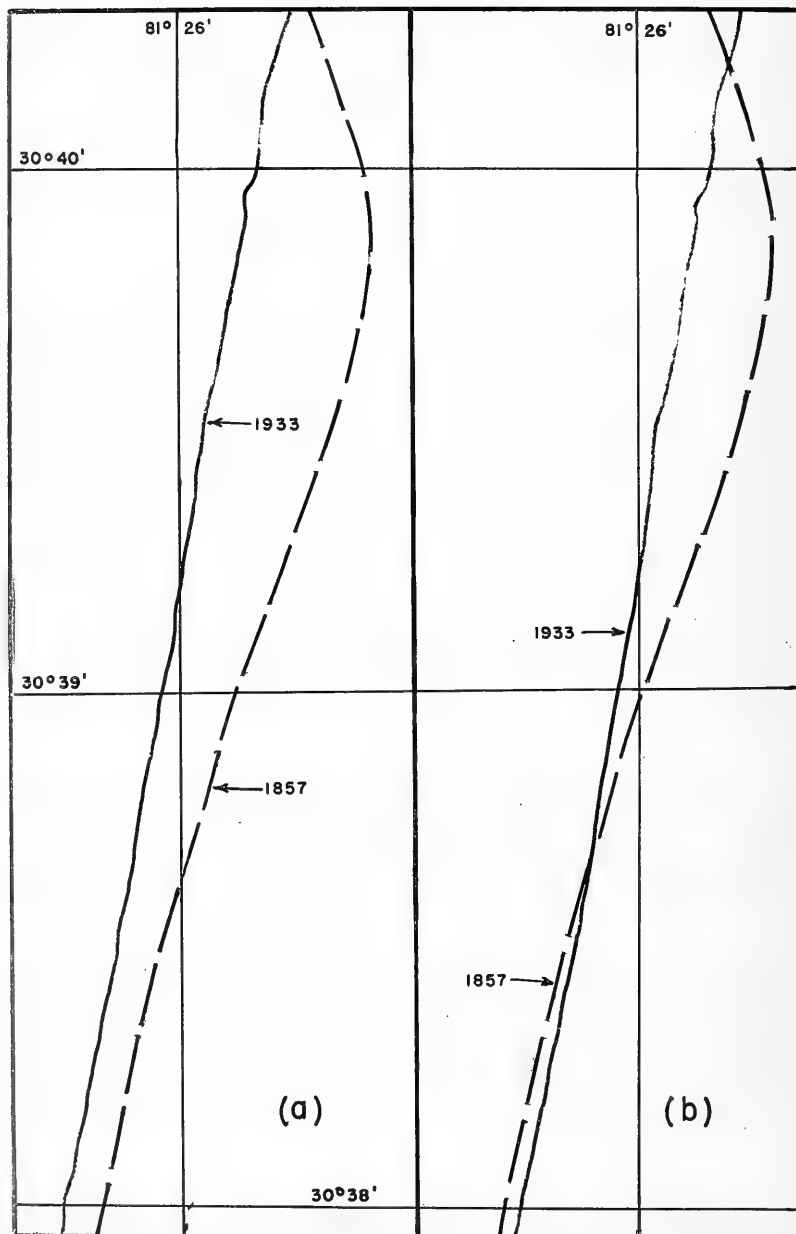
The long-term behavior of the shore line and offshore depths is one of the important factors considered in devising a solution to beach erosion problems. Suitable historical topographic and hydrographic surveys are superposed to delineate the movement of the shore lines and offshore depth curves. The relative positions of the shore lines and depth curves at the times of the various surveys show the area of erosion or accretion, whether the movement has been constant, and how the introduction of other factors such as man-made structures, breaches of barrier beaches and the migration of inlets, etc. have altered the regime of the area under study.

The purpose of this article is to point out some of the cartographic problems that must be considered when old surveys are used to determine the long-term behavior of the shore lines and offshore depths. These valuable sources of information when properly used will give a factual history of the changes that have occurred. The past behavior of the beach is a tool in the analysis of the forces acting upon the shore, the amount of material in motion, etc., and can determine the most feasible means of harnessing the forces to solve the problem.

The U. S. Coast and Geodetic Survey in Washington, D. C., is the primary source of general historic surveys for this purpose for the U. S. Coast of the Gulf of Mexico, Atlantic and Pacific Oceans. The vault of this agency contains approximately 15,000 original field sheets dating back to 1834. The high standards of accuracy of work performed over the period of record makes the field sheets invaluable for use in beach erosion studies.

In addition an incomplete file is preserved of "Descriptive Reports" carrying the registry number of the survey it describes. Oftimes the old descriptive reports give a graphic description of conditions found by the survey party, and of particular interest to the engineer studying erosion problems is "on the spot" comparison of circumstances with former surveys. The report for example, may mention changes caused by severe storms which have preceded or interrupted the work. To the engineer this means the shore line or depth curves as shown may be abnormal and must be appraised carefully.

It is important that superposed surveys be accurately placed on a common geodetic datum and in handling old historic surveys this sometimes presents a problem. The polyconic projection is used for practically all field sheets. Due to recomputations of the dimensions of the spheroid at various times the coordinates of triangulation stations have been adjusted; which, of course, necessitates replotting the latitude and longitude lines. In the earlier periods when there were relatively few field sheets in the



EFFECT BY ADJUSTMENT OF HORIZONTAL DATUM

FIGURE 1

files an entire new projection was applied to each. As more surveys were made and more adjustments required it was impractical to apply full projections to the sheets, therefore the practice in recent times has been to add only an occasional grid intersection to show the correction to be applied.

Two spheroids of reference, Bessel's and Clarke's, have been used by the U. S. Coast and Geodetic Survey. However, various datums have been used on each. The old Bessel's Datum was in use from 1834 to 1844 and the Bessel's spheroid of 1841 was used until 1880 when Clarke's spheroid of 1866 was adopted. The datums used on Clarke's spheroid have been:

Clarke's Datum	1880 - 1901
U. S. Standard Datum	1901 - 1915
North American Datum	1915 - 1927
North American 1927 Datum	1927 to date

The North American Datum and the U. S. Standard are the same, the only difference being the name. The term U. S. Standard was changed when the datums of Canada and Mexico were tied in to the U. S. network making it, as the name implies, a North American Datum.

In 1927 an adjustment of all first-order triangulation in the United States was begun based on station "Meades Ranch" in Kansas, which was selected because of its location near the center of area of the United States on two major arcs of triangulation extending across the country at right angles to each other, and because of the great amount of recomputation that could be avoided since no change would result in the network that had been extended to that point from the New England States and other coastal states southward to North Carolina. When the adjustment to this base has been made the stations are on the North American 1927 Datum. It is to this datum that the historic surveys are adjusted for superposing for study by beach erosion engineers.

A truly satisfactory method of showing shore line and offshore depth changes has not been developed. Many attempts have been made but none satisfy all conditions. The favored method used by the Beach Erosion Board is to adjust the graticules of each of the surveys to be used to the North American 1927 Datum. This gives a projection common to all sheets. A composite tracing is made of the shore lines and selected offshore depth curves using symbols to differentiate between the various periods. The lateral shift of the shore line and depth curves can then be determined.

It has been mentioned that the adjustment of some of the old surveys present a problem. These cases are rare. When such a sheet is found it should not be abandoned until a check has been made in the old records of the Geodesy Section and in old publications of the Coast and Geodetic Survey which give the position of "lost" stations.

Old sheets on which no recent datum has been indicated can sometimes be adjusted by the use of stations which are common to another sheet of a later or earlier period or between the topographic and hydrographic survey of the same period on which a datum is given.

Photostat or bromide copies of field sheets can be obtained. Both methods of reproduction are subject to distortion and are difficult to use for precise purposes. Protective coverings of silk, acetate, etc., have been applied to some of the originals and these sheets do not copy well. Many lines were inked so finely they are lost in reproduction and inasmuch as these are the base to which corrections for datum are applied, their omission is an important factor.

The importance of getting the surveys properly adjusted can be seen by observing Figure 1; section (a) shows a section of a survey which has been superposed without adjustment, section (b) shows the same area when the adjustment has been applied.

The use of old editions of published charts as a substitute for the original field sheets in compiling changes in shore lines and depth curves is to be discouraged unless it is done by someone thoroughly familiar with the methods in use in the various periods. The projection shown on such a chart will be on the datum currently in use at the time of publication. Several governmental departments other than the Coast Survey furnish data that are used to revise charts, particularly at inlets and harbor entrances where from a navigational standpoint the changes are sufficiently important to warrant a new edition being published. Except for the local revised areas the information shown on the new edition is based on the previous general surveys of the area and does not reflect conditions as of the date of publication. The Coast and Geodetic Survey keeps a record of surveys by other agencies that are used to revise charts and while it is possible to break the edition down to show the date, source, and extent of all revisions, it is only on rare occasions that this is justified. Working from the field sheets is much to be preferred.

In the use of historic hydrographic surveys, an evaluation of the depth curves should be made based on the methods used in the different periods. The earlier surveys were made using sailing ships and handpulled boats. The depth curves are of necessity generalized and do not, in most cases, delineate the bottom conditions sufficiently for relative comparison with modern surveys.

It is also well to keep in mind that surveys by the Coast and Geodetic Survey are made primarily for use by mariners. It is the practice of cartographers to include representative soundings in the placement of the depth curves, whereas the engineer usually draws the depth curves through the representative sounding. When engineer surveys are used in conjunction with navigational surveys an erroneous movement of the depth curves may be indicated by reason of the methods used.

BEACH EROSION STUDIES

The principal types of beach erosion reports of studies at specific localities are the following:

- a. Cooperative studies (authorization by the Chief of Engineers in accordance with Section 2, River and Harbor Act approved on 3 July 1930).
- b. Preliminary examinations and surveys (Congressional authorization by reference to locality by name).
- c. Reports on shore line changes which may result from improvements of the entrances at the mouths of rivers and inlets (Section 5, Public Law No. 409, 74th Congress).
- d. Reports on shore protection of Federal property (authorization by the Chief of Engineers).

Of these types of studies, cooperative beach erosion studies are the type most frequently made when a community desires investigation of its particular problem. As these studies have, consequently, greater general interests, information concerning studies of specific localities contained in these quarterly bulletins will be confined to cooperative studies. Information about other types of studies can be obtained upon inquiry to this office.

Cooperative studies of beach erosion are studies made by the Corps of Engineers in cooperation with appropriate agencies of the various States by authority of Section 2 of the River and Harbor Act approved on 3 July 1930. By executive ruling the cost of these studies is divided equally between the United States and the cooperating agency. Information concerning the initiation of a cooperative study may be obtained from any District Engineer of the Corps of Engineers. After a report on a cooperative study has been transmitted to Congress, a summary thereof will be included in the next issue of this bulletin. A list of completed cooperative studies and of those now in progress follows:

SUMMARY OF REPORT TRANSMITTED TO CONGRESS

HARRISON COUNTY, MISSISSIPPI

Harrison County is located on the Gulf coast of Mississippi about midway between Mobile, Alabama, and New Orleans, Louisiana. The portion of the coast investigated extends from Biloxi at the entrance to Biloxi Bay on the east to Henderson Point at the entrance to St. Louis Bay on

the west, a distance of about 27 miles. The general direction of the coast in this area is east and west. A chain of low, narrow, sand islands lies from 8 to 12 miles off the area, separated from the mainland by Mississippi Sound.

The principal cities and towns in Harrison County are Biloxi, Gulfport, Long Beach, and Pass Christian, all on the coast within the study area. They are interconnected by U. S. Highway 90, the main highway along the Gulf coast from Florida to Louisiana, also by a secondary road and by the main line of the Louisville and Nashville Railroad. In 1940 the combined population of these communities was about 37,500. The entire area is a summer resort center. Fine summer houses are maintained there by residents of inland cities and other States. Hotels and recreational facilities are also available.

For almost its entire length across Harrison County, U. S. Highway 90 lies close to the Gulf and is protected by sea walls. The most important of these is the reinforced concrete step-type wall built by the county between 1925 and 1928. Its total length is 24 miles. This wall consists of sections 28 feet long supported by square concrete piles and by a continuous concrete sheet pile curtain wall at the toe. Part of the wall has a top elevation of 11 feet and part 8 feet above mean sea level. A concrete sidewalk 5 feet wide adjoins the top of the wall throughout its length. Sand backfill for the sea wall and adjacent roadway was dredged from Mississippi Sound about 1,000 feet offshore. The total cost of the protective walls was \$3,400,000.

The bottom of Mississippi Sound off the sea wall consists of medium to fine sand with a small percentage of silt and clay. It is reported that a sandy beach existed in front of the sea wall when it was built. The only beaches in front of the sea wall at present are at Biloxi and Gulfport, where local interests have created small beaches by dredging sand from offshore. These beaches are publicly-owned and the public has unrestricted access to them at all times. In 1936 a system of concrete sheet-pile groins was built for the protection of the artificially created beach along about 1 mile of waterfront at Biloxi. The groins are spaced generally at intervals of about 250 feet, and are 150 to 200 feet long.

The disappearance of the protective beach from in front of the sea wall has exposed the sheet-pile curtain wall to direct wave action at all normal stages of tide. Deterioration of this curtain wall and of the drainage system through the wall permitted the escape of sand backfill, especially since the protecting beach was lost. The loss of backfill caused settlement and breakage of the sidewalk and endangered the parallel highway at some places. This condition was aggravated as a result of the 1947 hurricane. Loss of backfill (some of which accumulated on the beach), destruction of the sidewalk and damage to the highway were extensive at that time. In addition, 5 short sections of the sea wall were destroyed.

In 1944 the Beach Erosion Board completed a study of the problem of protection of Harrison County. The Board recommended the immediate initiation of repairs to the sea wall, the construction of an artificial beach, and the institution of an adequate program of periodic inspection and maintenance of both the beach and the sea wall. The Board stated that

no share of the expense of any improvement should be borne by the United States. None of the recommended work has been accomplished.

In view of the new policy of Federal assistance in the construction of works for the improvement and protection of publicly-owned shores against erosion by waves and currents, set forth in Public Law 727, 79th Congress approved August 13, 1946, the recent investigation was initiated to supplement the previous report of the Beach Erosion Board primarily to determine the extent of Federal participation. The District Engineer at Mobile, Alabama and the Division Engineer, South Atlantic Division, furnished the basic report in which they considered the desires of the cooperating agency, studied the changes in local conditions since the 1944 report by the Board, including the effects of the hurricane of September 1947, and made an economic analysis of the existing and proposed protective measures. As a result of these data the Board concluded that the plan of improvement should include repair of the sea wall and its protection by an artificial beach 300 feet wide as previously recommended.

The Board studied a proposed drainage plan to provide a collecting sewer in back of the bar discharging through relatively few large drains across the beach, also the less expensive alternative of extending the numerous existing drains across the beach. It was not satisfied that either of these drainage systems could be maintained and not be injurious to the beach, but believed that efforts should be made in the detailed design stage to avoid, if possible, the long drains across the beach.

U. S. Highway 90 which lies immediately behind the sea wall is the main traffic artery along the Gulf Coast from Florida to the West. In view of its value both to normal traffic and to national defense, the Board concluded that the highway protected by the Harrison County sea wall is sufficiently important to justify protection. The Board therefore considered that the maximum amount under the policy stated in Public Law 727, 79th Congress, namely one-third of the original cost of the wall, is applicable in this case. As the original cost of the wall was \$3,400,000, one-third thereof would amount to \$1,133,000. The Board therefore concluded that Federal contribution in amount not exceeding \$1,133,000 is warranted toward the repair of the wall and protection thereof by the building of an artificial beach and necessary drainage facilities, subject to certain conditions of local cooperation. The beach should be constructed by placing approximately 5,700,000 cubic yards of sand in front of the wall from the offshore bottom at least 1,500 feet distant from the wall.

In accordance with existing statutory requirements, the Board stated its opinion as follows:

- a. It is advisable for the United States to adopt a project, authorizing Federal contribution toward the cost of repairing the Harrison County sea wall and the protection thereof by the construction of an artificial beach in front of the wall with necessary drainage facilities;

- b. The public interest involved in the proposed improvement is associated with the ownership of real property in the area, the value of the important Federal Aid highway, both as a normal traffic artery and as a necessity to national defense and security, and the recreational benefits that will accrue to the general public. It is sufficient to warrant Federal participation in accordance with the policy set forth in Public Law 727, 79th Congress;
- c. The share of the expense of the total improvement which should be borne by the United States is \$1,133,000, one-third of the original cost of the wall.

The Board recommended that a project be adopted by the United States authorizing Federal participation in the amount of \$1,133,000 toward the repair of the Harrison County sea wall and its protection by the construction of a beach from Biloxi Lighthouse to Henderson Point, Mississippi, with attendant drainage facilities. The beach should have a berm elevation of 5 feet and a width of 300 feet, above mean sea level. It would be constructed by the deposit of approximately 5,700,000 cubic yards of sand in front of the wall. Federal participation is recommended subject to the conditions that the State of Mississippi and Harrison County will:

- a. Assure maintenance of the sea wall and drainage facilities, and of the beach by artificial replenishment, during the useful life of these works, as may be required to serve their intended purpose;
- b. Hold and save the United States free from all claims for damages that may arise either before, during or after prosecution of the work.
- c. Provide, at their own expense, all necessary lands, easements and rights-of-way;
- d. Prevent water pollution that would endanger the health of bathers;
- e. Assure perpetual public ownership of the beach and its administration for public use only.

The Board further recommended that the adequacy of work proposed by local authorities, detailed plans, specifications, assurances that the requirements of local cooperation will be met and arrangements for prosecuting the entire project be approved by the Chief of Engineers prior to commencement of work.

COMPLETED COOPERATIVE BEACH EROSION STUDIESMAINE

OLD ORCHARD BEACH. Completed on 20 September 1935. Cooperating Agency: State of Maine (Acting through Maine State Planning Board).

NEW HAMPSHIRE

HAMPTON BEACH. Completed on 15 July 1932. Cooperating Agency: State of New Hampshire (Acting through New Hampshire Shore and Beach Preservation and Development Commission).

MASSACHUSETTS

SOUTH SHORE OF CAPE COD (CHATHAM TO POINT GAMMON). Completed on 26 August 1941. Cooperating Agency: Commonwealth of Massachusetts (Acting through Massachusetts Department of Public Works).

WINTHROP BEACH. Completed on 12 September 1947. Cooperating Agency: Commonwealth of Massachusetts (Acting through Massachusetts Department of Public Works).

RHODE ISLAND

NARRAGANSETT. Interim report on the shore of the Town of Narragansett prepared on 27 September 1946. Cooperating Agency: State of Rhode Island (Acting through Rhode Island Department of Public Works).

WESTERLY. Interim report on the shore of the Town of Westerly prepared on 11 December 1946. Cooperating Agency: State of Rhode Island (Acting through Rhode Island Department of Public Works).

CONNECTICUT

HAWK'S NEST BEACH, OLD LYME. Completed on 21 June 1939. Cooperating Agencies: Town of Old Lyme and Hawk's Nest Association.

COMPO BEACH, WESTPORT. Completed on 18 April 1935. Printed in House Document No. 239, 74th Congress, 1st Session. Cooperating Agency: State of Connecticut (Acting through Board of Selectmen, Town of Westport).

NEW YORK

JACOB RIIS PARK, LONG ISLAND. Completed on 16 December 1935. Printed in House Document No. 397, 74th Congress, 2d Session. Cooperating Agency: State of New York, (Acting through Department of Parks, City of New York).

ORCHARD BEACH, PELHAM BAY, BRONX. Completed on 30 August 1937. Printed in House Document No. 450, 75th Congress, 2d Session. Cooperating Agency: Department of Parks, City of New York.

NIAGARA COUNTY. Completed on 27 June 1942. Printed in House Document No. 271, 78th Congress, 1st Session. Cooperating Agency: Niagara Frontier Planning Board, Buffalo, New York.

SOUTH SHORE OF LONG ISLAND. Joint report completed on 6 August 1946. Cooperating Agency: Long Island State Park Commission and Suffolk County.

NEW JERSEY

MANASQUAN INLET AND ADJACENT BEACHES. Completed on 15 May 1936. Printed in House Document No. 71, 75th Congress, 1st Session. Cooperating Agency: State of New Jersey (Acting through Board of Commerce and Navigation).

VIRGINIA

WILLOUGHBY SPIT. Completed on 20 November 1937. Printed in House Document No. 482, 75th Congress, 3rd Session. Cooperating Agency: City of Norfolk, Virginia.

NORTH CAROLINA

FORT FISHER. Completed on 10 November 1931. Printed in House Document No. 204, 72d Congress, 1st Session. Cooperating Agency: State of North Carolina (Acting through North Carolina Department of Conservation and Development).

WRIGHTSVILLE BEACH. Completed on 2 January 1934. Printed in House Document No. 218, 73rd Congress, 2d Session. Cooperating Agency: State of North Carolina (Acting through North Carolina Department of Conservation and Development).

KITTY HAWK, NAGS HEAD, AND OREGON INLET. Completed on 1 March 1935. Printed in House Document No. 155, 74th Congress, 1st Session, Cooperating Agency: State of North Carolina (Acting through North Carolina Department of Conservation and Development).

STATE OF NORTH CAROLINA. Completed on 22 May 1947. Cooperating Agency: State of North Carolina (Acting through North Carolina Department of Conservation and Development).

SOUTH CAROLINA

FOLLY BEACH. Completed on 31 January 1935. Printed in House Document No. 156, 74th Congress, 1st Session. Cooperating Agency: State of South Carolina (Acting through Sanitary and Drainage Commission of Charleston, South Carolina).

GEORGIA

ST. SIMON ISLAND. Completed on 18 March 1940. Printed in House Document No. 280, 76th Congress, 3rd Session. Cooperating Agency: Glynn County, Georgia (Acting through Commissioners, Roads and Revenue of Glynn County).

FLORIDA

BLIND PASS (BOCA CIEGA). Completed on 1 February 1937. Printed in House Document No. 187, 75th Congress, 1st Session. Cooperating Agency: State of Florida (Acting through Engineering Experiment Station, University of Florida).

MIAMI BEACH. Completed on 1 February 1937. Printed in House Document No. 169, 75th Congress, 1st Session. Cooperating Agency: State of Florida (Acting through Engineering Experiment Station, University of Florida, and the City of Miami Beach).

HOLLYWOOD BEACH. Completed on 28 April 1937. Printed in House Document No. 253, 75th Congress, 1st Session. Cooperating Agency: State of Florida (Acting through Engineering Experiment Station, University of Florida, and the City of Hollywood Beach).

DAYTONA BEACH. Completed on 15 March 1938. Printed in House Document No. 571, 75th Congress, 3rd Session. Cooperating Agency: State of Florida (Acting through Engineering Experiment Station, University of Florida).

BAKERS HAULOVER INLET. Completed on 21 May 1945. Printed in House Document No. 527, 79th Congress, 2d Session. Cooperating Agency: Board of County Commissioners, Dade County.

PALM BEACH. Interim report prepared on 19 September 1941. Cooperating Agency: State of Florida (Acting through Engineering Experiment Station, University of Florida).

PALM BEACH. Completed on 13 February 1947. Cooperating Agency: Port of Palm Beach District.

JUPITER ISLAND. Completed on 13 February 1947. Cooperating Agency: State of Florida (Acting through Florida State Improvement Association).

ANNA MARIA AND LONGBOAT KEYS. Completed on 12 February 1947. Cooperating Agency: Manatee County (Acting through Manatee County Board of County Commissioners).

MISSISSIPPI

HANCOCK COUNTY. Completed 3 April 1942. Cooperating Agency: Board of Supervisors, Hancock County, Mississippi.

HARRISON COUNTY. Completed on 15 March 1944. Supplement completed on 16 February 1948. Cooperating Agency: Harrison County Board of Supervisors.

LOUISIANA

GRAND ISLE. Completed on 28 July 1936. Printed in House Document No. 92 75th Congress, 1st Session. Cooperating Agency: State of Louisiana (Acting through State Board of Engineers).

TEXAS

GALVESTON. Completed on 10 May 1934. Printed in House Document No. 400, 73rd Congress, 2d Session. Cooperating Agency: Court of County Commissioners, Galveston County.

GALVESTON BAY, HARRIS COUNTY. Completed on 31 July 1934. Printed in House Document No. 74, 74th Congress, 1st Session. Cooperating Agency: Court of County Commissioners, Harris County.

CALIFORNIA

SANTA BARBARA. Completed on 15 January 1938. Printed in House Document No. 552, 75th Congress, 3rd Session. Supplement completed on 18 February 1942. Final report completed on 22 May 1947. Cooperating Agency: City and County of Santa Barbara (Acting through Board of Harbor Commissioners and City Engineer of Santa Barbara).

BALLONA AND SAN GABRIEL RIVER. Completed on 11 May 1938. Local interests requested that the study be terminated before all the field data were submitted. Report was prepared based on the data that had been submitted. Cooperating Agency: State of California (Acting through Los Angeles Flood Control District).

ORANGE COUNTY. Completed on 10 January 1940. Printed in House Document No. 637, 76th Congress, 3rd Session. Cooperating Agency: County of Orange, California (Acting through Orange County Board of Supervisors).

CORONADO BEACH. Completed on 4 April 1941. Printed in House Document No. 636, 77th Congress, 2d Session. Cooperating Agency: City of Coronado.

LONG BEACH. Completed on 3 April 1942. Cooperating Agency: City of Long Beach, California.

MISSION BEACH. Completed on 4 November 1942. Cooperating Agency: City of San Diego (Acting through Council of the City of San Diego).

PENNSYLVANIA

PRESQUE ISLE PENINSULA, ERIE. Interim report prepared on 3 April 1942. Cooperating Agency: Commonwealth of Pennsylvania (Acting through State Park and Harbor Commission of Erie).

OHIO

LAKE ERIE SHORE LINE - MICHIGAN LINE TO MARLEHEAD. Completed on 30 October 1944. Printed in House Document No. 177, 79th Congress, 1st Session. Cooperating Agency: State of Ohio (Acting through Department of Public Works).

LAKE ERIE SHORE LINE - VICINITY OF HURON. Completed on 26 August 1941. Printed in House Document No. 220, 79th Congress, 1st Session. Cooperating Agency: Erie County (Acting through Department of Engineering, Erie County).

LAKE ERIE SHORE LINE - CITIES OF CLEVELAND AND LAKEWOOD. Completed on 22 March 1948. Cooperating Agency: City of Cleveland.

WISCONSIN

LAKE MICHIGAN SHORE LINE OF MILWAUKEE COUNTY. Completed on 21 May 1945. Printed in House Document No. 526, 79th Congress, 2d Session. Cooperating Agency: County of Milwaukee (Acting through Milwaukee County Board of Supervisors).

PUERTO RICO

SAN JUAN. Completed on 5 August 1947. Cooperating Agency: Government of Puerto Rico (Acting through the Commissioner of the Interior).

COOPERATIVE BEACH EROSION STUDIES IN PROGRESSNEW HAMPSHIRE

HAMPTON BEACH. Cooperating Agency: New Hampshire Shore and Beach Preservation and Development Commission.

Problem: To determine the best methods of preventing further erosion and of stabilizing and restoring the beaches; also to determine the extent of silting and erosion in the harbor.

MASSACHUSETTS

METROPOLITAN DISTRICT BEACHES, BOSTON. Cooperating Agency: Metropolitan District Commission (for the Commonwealth of Massachusetts).

Problem: To determine the best methods of preventing further erosion, of stabilizing and improving the beaches, and of protecting the sea walls of Lynn Shore Reservation, Nahant Beach Parkway, Revere Beach, Quincy Shore, Nantasket Beach.

SALISBURY BEACH. Cooperating Agency: Department of Public Works (for the Commonwealth of Massachusetts).

Problem: To determine the best methods of preventing further beach erosion. This will be a final report to report dated 26 August 1941.

RHODE ISLAND

STATE OF RHODE ISLAND. Cooperating Agency: State of Rhode Island (Acting through Rhode Island Department of Public Works).

Problem: To determine the best method of restoring and protecting shore lines against damage from storms and hurricanes on the south shore of Rhode Island from Clump Rocks east of the mouth of the Pettaquamscutt River to the Connecticut State Line.

CONNECTICUT

STATE OF CONNECTICUT. Cooperating Agency: State of Connecticut (Acting through the Flood Control and Water Policy Commission).

Problem: To determine the most suitable methods of stabilizing and improving the shore line. Sections of the coast will be studied in order of priority as requested by the cooperating agency until the entire coast is included.

NEW JERSEY

ATLANTIC CITY. Cooperating Agency: City of Atlantic City.

Problem: To determine the best methods of preventing further beach erosion.

VIRGINIA

COLONIAL BEACH. Cooperating Agency: Department of Highways (for the Commonwealth of Virginia).

Problem: To formulate a master plan for the improvement of the beach and to determine the best method of arresting erosion of the bank adjacent to the State Highway at Colonial Beach.

VIRGINIA BEACH. Cooperating Agency: Town of Virginia Beach.

Problem: To determine methods for the improvement and protection of the beach and existing concrete sea wall.

LOUISIANA

LAKE PONTCHARTRAIN. Cooperating Agency: Board of Levee Commissioners, Orleans Levee District.

Problem: To determine the best method of effecting necessary repairs to the existing sea wall and the desirability of building an artificial beach to provide protection to the wall and also to provide additional recreational beach area.

TEXAS

GALVESTON COUNTY. Cooperating Agency: County Commissioners Court of Galveston County.

Problem: To determine the best method of providing a permanent beach and the necessity for further protection or extending the sea wall within the area bounded by the Galveston South Jetty and Eight Mile Road.

CALIFORNIA

STATE OF CALIFORNIA. Cooperating Agency: Division of Beaches and Parks State of California.

Problem: To conduct a study of the problems of beach erosion and shore protection along the entire coast of California. The initial studies are to be made in the Ventura-Port Hueneme area and the Santa Monica area.

ILLINOIS

STATE OF ILLINOIS. Cooperating Agency: Department of Public Works and Buildings, Division of Waterways, State of Illinois.

Problem: To determine the best method of preventing further erosion and of protecting the Lake Michigan shore line within the Illinois boundaries.

OHIO

STATE OF OHIO. Cooperating Agency: State of Ohio (Acting through the Superintendent of Public Works).

Problem: To determine the best method of preventing further erosion of and stabilizing existing beaches, of restoring and creating new beaches, and appropriate locations for the development of recreational facilities by the State along the Lake Erie shore line.

PENNSYLVANIA

PRESQUE ISLE. Cooperating Agency: State Parks and Harbor Commission of Erie (for the Commonwealth of Pennsylvania).

Problem: To determine the best method of preventing further erosion and stabilizing the beaches of Presque Isle Peninsula at Erie, Pennsylvania. This will be a supplemental report to the report dated 3 April 1942.

MISSISSIPPI

HANCOCK COUNTY. Cooperating Agency: Board of Supervisors of Hancock County.

Problem: To determine the best method of repairing the existing sea wall and protecting it from further damage and to determine what share of the cost of any recommended plan should be borne by the United States as provided in Public Law 727, 79th Congress.

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BEACH EROSION LITERATURE

There are listed below some recent acquisitions of the Board's library which are considered to be of general interest. Copies of these publications can be obtained on 30 day loan by field offices of the Corps of Engineers and other Government agencies.

"Revised Wave Forecasting", Scripps Institution of Oceanography, Wave Report No. 73, March 1948, 14 pp., 10 plates.

The basic theory and technique of forecasting wind waves and swell are given in H. O. Publication No. 601 (1947) and H. O. Misc. No. 11275 (1943) both obtainable from the Hydrographic Office, U. S. Navy, Suitland, Maryland. The present paper includes revised forecasting graphs in the form of their original presentation, and in the form of nomographs or alignment charts. Research and experience have shown that forecasting results are improved by certain changes in the procedure for evaluating variables from weather map data which are summarized in this report.

"The Partition of Energy in Periodic Irrotational Waves on the Surface of Deep Water", George W. Platzman, University of Chicago, Journal of Marine Research, v.6, no. 3, 1947, p 194.

The paper presents general formulae for the potential and kinetic energy of deep water waves in terms of coefficients in the series employed by Stokes, from which the energy may be computed to whatever order these coefficients are known. The kinetic energy, e , and the potential energy, v , are expressed as power series in B , the determination being carried to the eighth order. A B-series is then derived for the ratio $(e - v)/v$, from which it is shown that the maximum value of this ratio, corresponding to the highest wave, is approximately $1/8$.

"Measurement of Transient Hydraulic Pressures" L. M. Montgomery and James W. Ward, The Review of Scientific Instruments, v.18, no. 5, May 1947.

Several methods of measuring transient pressure waves in water are described; including piezoelectric crystals, electromagnetic pickups, balanced diaphragms, high speed stroboscopic pictures of small rubber balloons, and cylindrical wire strain gages. Only the cylindrical wire strain gage was found satisfactory. The method of calibration, response characteristics, and operation of the gage are described.

"Generation and Propagation of Ocean Waves and Swell", N. F. Barber and F. Ursell, Philosophical Transactions of the Royal Society of London, Series A, v.240, no.824, pp 527-560, February 1948.

Studies of three cases of propagated swell lead to the conclusions that: (1) swell propagation is linear, so that trains of swell of different length and period behave independently; (2) waves are propagated with the classical group velocity appropriate to their period; (3) there is an upper limit to the wave period generated by a wind of given strength, the limit being an increasing function of the wind strength. Interesting features of the paper aid the use of wave propagation diagrams and wave spectra obtained from analysis of sub-surface pressure records.

- "A Critical Wind Speed for Air-Sea Boundary Processes", Walter H. Munk, *The Journal of Marine Research*, v.6, no. 3, p.203, 1947.

Most processes at the air-sea boundary are modified by the existing wind pattern. A number of apparently unrelated processes undergo abrupt changes at a critical wind speed. The Kelvin-Helmholtz instability criterion applied to the air-sea boundary gives instability at about the same critical wind speed. The application involves the transition from laminar to turbulent flow. Discussions of applications to sea gull soaring, occurrence of whitecaps, resistance coefficient of the sea surface, and evaporation phenomena are included. The initial formation of waves and the breaking of waves in the open sea are not treated.

- "An Elementary Theory of the Land and Sea Breeze Circulation", F. H. Schmidt, *Journal of Meteorology*, v. 4, no. 1, pp. 9-15, February 1947.

The problem of pure land and sea breezes is treated in an elementary way, presupposing the existence of a certain atmospheric temperature distribution. The effect of wind distribution on the temperature distribution thus is ignored. The deflecting force of the earth's rotation is considered, resulting in a finding that the sea breeze does not always blow perpendicular to the coast.

- "The Effect of a Fixed Vertical Barrier on Surface Waves in Deep Water", F. Ursell, *Proc. Cambridge Philosophical Society*, v.43, pt.3, pp. 374-382, July 1947.

The paper reports a theoretical study of the two-dimensional reflection of surface waves from a vertical barrier in deep water. Transmission and reflection coefficients for a vertical barrier extending to various depths are derived, and discussion is included of the phase change at a barrier in the surface. Extension of the method to other positions of the barrier is described.

- "Suspended Matter Sampling and Current Observations in the Vicinity of Hunters Point, San Francisco Bay", J. A. Putnam, K. J. Bermel, J. W. Johnson, *Trans. A.G.U.*, v. 28, no.5, pp. 742-746, October 1947.

Data summarized in the paper concern current velocities and directions, turbidity, and temperature of a part of south San Francisco Bay. A brief description of the measuring techniques employed is given.

"Wave Action on Structures", Walter H. Munk, American Institute of Mining and Metallurgical Engineers, Technical Publication No. 2322, March 1948.

Wave forces on structures are discussed in relation to the Airy wave theory. The principal value of the paper lies in the method presented for computation of forces and moments against vertical piles.

"Momentum and Energy Integrals for Gravity Waves of Finite Height", Victor P. Starr, University of Chicago, Journal of Marine Research, v.6, no. 3, p. 175, 1947.

Certain simple integral properties of gravity wave motion are derived directly from the differential equations governing the dynamic system considered. The treatment is restricted to plane waves in an irrotational medium which move without change of form. No assumption is made concerning the amplitude so that the results are applicable to waves of finite height. Both periodic and solitary waves are considered.

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